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# Art. IV.—*Notes on the Jurassic Rocks of the Barrabool Hills, near Geelong, Victoria.*

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(With Plate I.)

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## Introduction.

The Barrabool Hills comprise the fertile "rolling downs" agricultural country to the west of Geelong, between the townships of Highton (3 miles) and Gnarwarre (12 miles). The hills were once well timbered, but were cleared about 80 years ago, and are now remarkably bare and treeless.

Two east-flowing streams—the Barwon River and the Waurn Ponds Creek—drain the northern and southern faces of the hills, and their tributary creeks have carved the soft Jurassic sandstone into a series of rounded hills and spurs. The hills thus present the mature erosion topography characteristic of a region of slight relief.

## Nature of the work done.

The map herewith shows for the first time the extent of Jurassic rocks in the Barrabool Hills. The eastern portion of the hills was included in Quarter Sheets 24 S.E. and 28 N.E. of the Geological Survey of Victoria, mapped by R. Daintree in 1861-2. Certain minor corrections have been made to this part, and the western portion has been added.

Dips were determined at every available outcrop, and the plotting of these led to the recognition of an unsuspected fault between the Jurassic basal beds and the normal sandstone beds.

Particular attention was given to the basal beds, where a fine series of conglomerates, sandstones, and fossiliferous mudstones is exposed in a river cliff on the Barwon, at the spot on the map marked "Basal Conglomerate." The collection of fossil flora obtained from the mudstone bands has clearly indicated the Lower Jurassic character of the basal beds.

Description of the Palaeozoic igneous rocks in the area has already been made (1), but the Kainozoic series has not yet been fully studied, and description of this is postponed. The debatable question of the origin of the Jurassic rocks is also deferred until more evidence is obtained.

## Palaeontology.

A resumé of the recorded fossils from the Victorian Jurassic has been published by Mr. W. H. Ferguson (2). References to general geological and mining work on the Jurassic have been compiled by Prof. J. W. Gregory (3).

In the display cases at the National Museum, Melbourne, there are 3 specimens of Jurassic plants from the Barrabool Hills. These were presented by the Mines Department in 1903, and it is understood that Mr. (afterwards Sir) R. Daintree collected them while mapping Quarter Sheet 24 S.E. The forms are *Baiera subgracilis,* McCoy; *B. ipsviciensis,* Shirley; *Taeniopteris spatulata,* McClell. var. *Daintreei,* McCoy.

Mr. F. Chapman (4, p. 216) has recorded *Taeniopteris spatulata* McClell. var. *Daintreei,* McCoy, from Barrabool Hills.

Mr. G. B. Hope, of Geelong, has collected from a mudstone band in Queen's Park and the Newtown Brick pit nearby, the forms *Equisetites* sp.; *Sphenopteris maccoyi,* Sew.; *Taeniopteris spatulata,* McClell. var. *Daintreei,* McCoy; *Dictyophyllum* sp.; *Linguiofolium* sp.

From the fine grey mudstone intercalated with the basal boulder beds at the river cliff on the Barwon, I have collected numerous leaf impressions which Mr. R. A. Keble has identified as follow:—

EQUISETALES.

2. Equisetites sp.

FILICALES.

4. Coniopteris hymenophylloides, Brongn. var. Australica, Sew.
1. Coniopteris sp. (?)
27. Sphenopteris ampla, McCoy.
5. Sphenopteris sp.
7. Taeniopteris spatulata, McClell. var. Daintreei, McCoy.
5. Taeniopteris spatulata, var. Carruthersi, T. Woods.
2. Cladophlebis denticulata, Brongn. var. Australis, Morris.
1. Taeniopteris crassinervis, Feistl.
4. Cladophlebis indica, Old. and Morris.
1. Cladophlebis sp.
1. Thinnfeldia cf. indica, Feistl.
1. Thinnfeldia sp.
1. Dictyophyllum sp.

GINKGOALES.

2. Ginkgo digitata, McCoy var. Huttoni, Sew.
5. Ginkgo sp.
4. Baiera Australis, McCoy.

CONIFERALES.

3. Araucaria sp.
2. Brachyphyllum Gippslandicum, McCoy.
1. Palissya (?) sp.
1. Cyparissidium sp.

GYMNOSPERMAE.

2. Carpolithes sp.

Mr. Keble commented on the collection thus: "The flora is in many respects comparable with the *Sphenopteris ampla* beds from Archie's Creek (Chapman, F., Jurassic Plant Remains from Gippsland, *Rec. Geol. Surv. Vic.*, iii (2), p. 107), and Binginwarri (idem, p. 108). The *Ginkgo* and *Baiera* element suggests a lower part of the series. There are 7 specimens of *Ginkgo* and 4 specimens of *Baiera,* and a number of indeterminate fragments of both genera, so that the Ginkgoales are relatively well represented. A single specimen of *B. australis* is recorded from one of the Binginwarri collections (idem, p. 108), in the same association, and similarly from Jumbunna (idem, p. 106), which shows that, while it is present, it is not a common form. The opinion is expressed here that the Barrabool Hills beds at Ceres are older than those at Binginwarri and Jumbunna. They are still apparently Jurassic, but the age of the underlying series is problematical, and we know by bores that there is a Mesozoic series at least 1500 feet thick at Jumbunna."

Only about 27 feet thickness of beds is exposed under the fossiliferous mudstone band, and from the structural features it is doubtful whether more than 100 feet of Jurassic would be passed through below that band before the bed-rock was met. There is little likelihood that the Jurassic series passes comformably downwards into beds of Lower Mesozoic age.

## Lithology.

The Barrabool Hills rock is almost exclusively a brown felspathic sandstone (5, p. 190) of medium grain, with occasional thin bands of fine grey mudstone separating the thick sandstone beds. Near the base of the series the beds are coarser sandstones and grits. The conglomerates and boulder beds appear to be truly basal in position.

False bedding, carbonaceous laminae, small "clay pellets," and hard ovoidal indurations ("bullets") of calcareous matter, occur in the sandstone; these features are characteristic of the Victorian Jurassic. Small included fragments of slate (? Ordovician) are also common in the Barrabool sandstone.

Near Pollocksford, at the place marked on the map, "Gravel Conglomerate," there is a coarse grit, composed of rounded pebbles of quartz and slate fragments, interstratified with the normal sandstone beds.

The remarkable basal boulder beds and conglomerates are best seen on the face of the river cliff in the extreme south-eastern corner of the bend in the Barwon River, at the spot on the map marked "Basal Conglomerate." Talus obscures the beds elsewhere, but similar material can be traced to Buckley's Gorge about ½ mile east of the river cliff.

Reading from the top of the cliff to the water level, the beds are:—

| | |
|---|---|
| Sandstone and grit, normal type .. .. .. .. .. .. | 63′ |
| Conglomerate, type A .. .. .. .. .. .. .. .. .. .. .. | 2′ |
| Sandstone and grit, with slate inclusions .. .. .. .. | 6′ |
| Conglomerate, type B .. .. .. .. .. .. .. .. .. .. .. | 2′ |
| Sandstone, normal type .. .. .. .. .. .. .. .. .. .. | 1′6″ |
| Conglomerate, type B .. .. .. .. .. .. .. .. .. .. .. | 0′6″ |
| Sandstone, normal type .. .. .. .. .. .. .. .. .. .. | 4′ |
| Conglomerate, type B, smaller pebbles .. .. .. .. .. | 1′ |

| | |
|---|---|
| Sandstone, normal type .. .. .. .. .. .. .. .. .. .. | 0′6″ |
| Boulder bed, type C .. .. .. .. .. .. .. .. .. .. .. .. | 20′ |
| Mudstone, fine grey carbonaceous, with flakes of mica. Fossil bed .. .. .. .. .. .. .. .. .. .. .. .. | 2′ |
| Conglomerate, type B .. .. .. .. .. .. .. .. .. .. .. | 0′3″ |
| Mudstone, fine grey carbonaceous, as above .. .. .. | 1′9″ |
| Boulder bed, type C. .. .. .. .. .. .. .. .. .. .. .. | 6′ |
| Sandstone, normal type .. .. .. .. .. .. .. .. .. .. | 16′ |
| Grit, resembling arkose .. .. .. .. .. .. .. .. .. .. | 2′6″ |
| Conglomerate, type B, only partly visible .. .. .. | 2′ |
| Total .. .. .. | 131′0″ |

The distinction into types A, B and C among the conglomerates has been made because of differences in the size and nature of their pebbles. All the pebbles are waterworn and partly rounded, and are embedded in a matrix of much smaller pebbles and felspathic sand. Calcareous matter cements the whole, and has formed vertical veins of calcite through the beds.

The pebbles comprise: Heathcotian green epidiorite, Lower Palaeozoic pink granite, Ordovician black slate, quartzite, spotted slate, Ordovician white quartz, grey mica schist, and Jurassic mudstone, sandstone and grit.

In type A conglomerate the Ordovician pebbles predominate, with fragments of Jurassic rock next in importance, and rare epidiorite and granite. The pebbles average about 2 in. diameter.

In conglomerate of type B the pebbles are about 4 in. in diameter, and consist of about equal amounts of epidiorite and Ordovician, with rare granite and Jurassic fragments.

Boulder bed C consists of pebbles in the same proportion as those of type B, but the boulders of epidiorite and granite are very large, up to 24 in. diameter.

The Ordovician material was identified by the discovery of graptolites in the slate pebbles by Mr. C. S. Wilkinson (6, p. 81).

Inclusion of fragments of Jurassic mudstone in Jurassic sandstone, etc., has also been recorded from South Gippsland (2, 7).

## Structural Features.

### *Absence of Supposed Anticlinal Fold.*

On Quarter Sheet 24 S.E. there is a line drawn in a N.E.-S.W. direction, roughly coincident with the course of the creek which meets the Barwon at the basal conglomerate cliff, and parallel to the section line AB of the present map, to indicate the axis of an anticlinal fold. Apparently the few dips shown on the Quarter Sheet furnished the evidence for this view, but the corrected dips fail to support the idea of an anticline. Actual folding of Jurassic strata has not been recorded in Victoria, and although the earlier workers, such as Daintree (8) and Wilkinson (9), represented folds in the sections they drew, more recent investigators, Whitelaw (10), Ferguson (2, 7), and Dunn (11) attribute the changes of dip to faulting.

### *Basal Beds Fault.*

In the area near the basal beds, there is a decided change of dip in the Jurassic beds; whereas the main block dips N.E. at about 10°, the basal beds have a strong dip of 30° to the South, almost directly opposed to this. The line of junction of the opposed dips runs E-W from Highton to the central epidiorite mass.

Two possible explanations of the opposed dips present themselves:—

(i.) There may be an asymmetrical syncline.

(ii.) Local sagging of the Jurassic along that line may have occurred, causing a fracture or fault between the two tilted blocks.

Insufficient outcrops are available to decide the point absolutely. Were the conglomerate beds constant and widespread, the fact that they do not reappear in the vicinity of Ceres township would be evidence against a syncline. But as with other Jurassic conglomerates, their horizontal distribution is very limited, and the beds probably "peter out" long before this. The second explanation, however, seems by analogy with other areas to be the more likely. Fig. 1 represents a section along the line ABC drawn in accordance with this view.

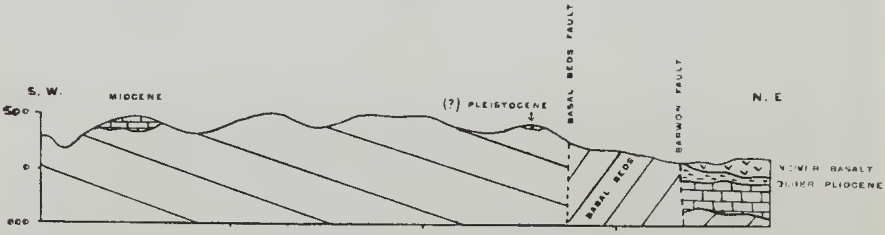
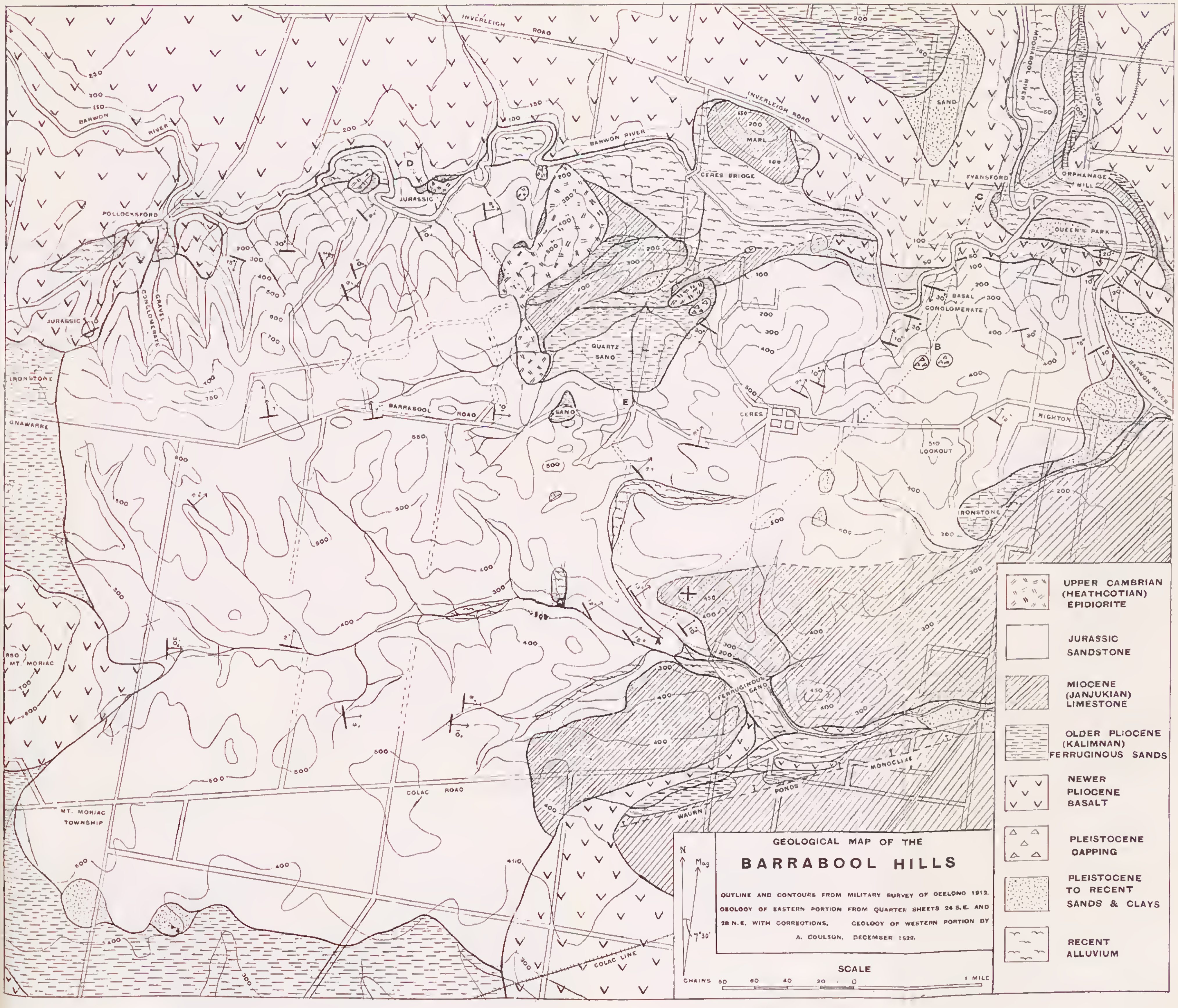



FIG. 1.—Sketch section along ABC.

### *Barwon Fault.*

Topographic and geological evidence is available for this fault, which runs E-W along the northern face of the Barrabools coincident with the course of the Barwon River. The let-down block to the north of the hills consists of Kainozoic sediments overlain by Newer Basalt. Similar Kainozoic sediments capping the Jurassic on the southern upthrow side of the fault are considerably higher than those of the let-down block. For example, the Miocene limestone in the let-down block has not been bottomed by the Cement Company's bores at Batesford, although these reached 50 ft. below sea-level. The base of the same limestone in the upthrow block, alongside the central epidiorite mass, is 100 ft. above sea-level. This gives a minimum throw of 150 ft., but judging from the elevation of the fault scarp, the throw was of the order of 400 ft. This fault is shown in Fig. 2, a section drawn along the line DE.


GEOLOGICAL MAP OF THE
BARRABOOL HILLS
OUTLINE AND CONTOURS FROM MILITARY SURVEY OF GEELONG 1912.
GEOLOGY OF EASTERN PORTION FROM QUARTER SHEETS 24 S.E. AND 28 N.E. WITH CORRECTIONS. GEOLOGY OF WESTERN PORTION BY A. COULSON. DECEMBER 1929.
SCALE
CHAINS 80 60 40 20 0 1 MILE
UPPER CAMBRIAN (HEATHCOTIAN) EPIDIORITE
JURASSIC SANDSTONE
MIOCENE (JANJUKIAN) LIMESTONE
OLDER PLIOCENE (KALIMNAN) FERRUGINOUS SANDS
NEWER PLIOCENE BASALT
PLEISTOCENE CAPPING
PLEISTOCENE TO RECENT SANDS & CLAYS
RECENT ALLUVIUM
INVERLEIGH ROAD
BARWON RIVER
POLLOCKSFORD
JURASSIC
CERES BRIDGE
MARL
SAND
FYANSFORD
ORPHANAGE MILL
QUEEN'S PARK
MOORABOOL RIVER
BASAL CONGLOMERATE
GRAVEL CONGLOMERATE
QUARTZ SAND
IRONSTONE
GNAWARRE
BARRABOOL ROAD
CERES
HIGHTON
LOOKOUT
MT. MORIAC
MT. MORIAC TOWNSHIP
COLAC ROAD
FERRUGINOUS SAND
MONOCLINE
PONDS
WAURN
COLAC LINE